

WHAT IS CLAIMED IS

1. A driving apparatus for driving a piezoelectric device serving as a driving source of an actuator comprising:

a waveform generator for generating a signal varying corresponding to passage of time;

a first driver for generating a first voltage signal having a maximum voltage smaller than a voltage of inversion of polarization of the piezoelectric device by using the signal from the waveform generator, and for applying the first voltage signal to the piezoelectric device in the polarization direction; and

a second driver for generating a second voltage signal having a maximum voltage smaller than the voltage of inversion of polarization of the piezoelectric device and the same polarity as that of the first driving signal by using the signal from the waveform generator, and for applying the second voltage signal to the piezoelectric device in a direction opposite to the polarization direction.

2. The driving apparatus in accordance with claim 1, wherein the second driving signal has a waveform which is an inversion of a waveform of the first driving signal.

3. The driving apparatus in accordance with claim 1, wherein the waveform of the first and second driving signals are a sine wave.

4. The driving apparatus in accordance with claim 1, wherein the waveform of the first and second driving signals are a sawtooth wave in which the inclination in a rising up portion is different from that in a falling down portion.

5. The driving apparatus in accordance with claim 1, wherein the first driver and the second driver respectively includes an amplifier for amplifying the signal from the waveform generator.

6. The driving apparatus in accordance with claim 1, wherein the actuator is an impact type actuator comprising a first unit with the piezoelectric device and a second unit slidably held on and relatively movable against the first unit.

7. An actuator comprising:

a first piezoelectric device serving as a driving source when a driving signal is applied in a polarization direction thereof;

a second piezoelectric device disposed for crossing the first piezoelectric device at a predetermined angle and for serving as a driving source when a driving signal is applied in a polarization direction thereof;

a driving member provided at a crossing point of the first and second piezoelectric devices and connected to top ends of the first and second piezoelectric devices;

two driving units respectively supplying driving signals to the first and second piezoelectric devices including the following three elements (a), (b) and (c):

(a) a waveform generator for generating a signal varying corresponding to the passage of time;

(b) a first driver for generating a first voltage signal having a maximum voltage smaller than a voltage of inversion of polarization of the piezoelectric device by using the signal from the

waveform generator, and for applying the first voltage signal to the piezoelectric device in the polarization direction; and

(c) a second driver for generating a second voltage signal having a maximum voltage smaller than the voltage of inversion of polarization of the piezoelectric device and the same polarity as that of the first driving signal by using the signal from the waveform generator, and for applying the second voltage signal to the piezoelectric device in a direction opposite to the polarization direction; and

a first controller for applying the driving signals from the driving units to the first and second piezoelectric devices with a predetermined phase difference so that the driving member is moved for trailing an ellipse or a circle and a driven object contacting to the driving member is mechanically driven.

8. The actuator in accordance with claim 7, wherein the second driving signal has a waveform which is an inversion of a waveform of the first driving signal.

9. The actuator in accordance with claim 7, wherein the waveform of the first and second driving signals are a sine wave.

10. The actuator in accordance with claim 7, wherein the waveform of the first and second driving signals are a sawtooth wave in which the inclination in a rising up portion is different from that in a falling down portion.

11. The actuator in accordance with claim 7, wherein the first driver and the second driver respectively includes an amplifier for

amplifying the signal from the waveform generator.

12. A driving apparatus for driving a piezoelectric device serving as a driving source of an actuator comprising:

a first circuit for gradually discharging electric charge from the piezoelectric device in a first direction; and

a second circuit for quickly charging electric charge into the piezoelectric device in a second direction opposite to the first direction.

13. The driving apparatus in accordance with claim 12, wherein

the first circuit includes a first switching circuit connected to a first current circuit for supplying a first current to the piezoelectric device;

the second circuit includes a second switching circuit connected to a second current circuit for supplying a second current which is larger than the first current to the piezoelectric device; and

the first switching circuit and the second switching circuit are alternatively switched on and off.

14. The driving apparatus in accordance with claim 12 further comprising:

a third circuit for gradually discharging electric charge from the piezoelectric device in the second direction;

a fourth circuit for quickly charging electric charge into the piezoelectric device in the first direction; and

a controller for controlling alternative of a group of the first

and second circuits and another group of the third and fourth circuits corresponding to a driving direction of the actuator.

15. The driving apparatus in accordance with claim 14, wherein

the first circuit includes a first switching circuit connected to a first current circuit for supplying a first current to the piezoelectric device;

the second circuit includes a second switching circuit connected to a second current circuit for supplying a second current which is larger than the first current to the piezoelectric device;

the third circuit includes a third switching circuit connected to a third current circuit for supplying a third current substantially the same intensity as the first current to the piezoelectric device;

the fourth circuit includes a fourth switching circuit connected to a fourth current circuit for supplying a fourth current which is substantially the same intensity as the second current to the piezoelectric device; and

the controller alternatively switching on and off the first switching circuit and the second switching circuit of the third switching circuit and the fourth switching circuit.

16. The driving apparatus in accordance with claim 12, wherein the actuator is an impact type actuator comprising a first unit with the piezoelectric device and a second unit slidably held on and relatively movable against the first unit.

17. A driving apparatus for driving a piezoelectric device

serving as a driving source of an actuator comprising:

a first driver for applying a voltage to the piezoelectric device in a polarization direction thereof; and

a second driver for applying a voltage equal to or smaller than a voltage of inversion of polarization of the piezoelectric device in a direction opposite to the polarization direction.

18. The driving apparatus in accordance with claim 17 further comprising a electric power supply for supplying electric power to the first and second drivers.

19. The driving apparatus in accordance with claim 17 further comprising a waveform generator for generating a signal varying corresponding to the passage of time, and wherein

only the first driver applies a voltage corresponding to the waveform of the signal when the signal from the waveform generator is larger than a predetermined level; and

both of the first and second driver respectively apply voltages corresponding to the waveform of the signal when the signal from the waveform generator is smaller than the predetermined level.

20. The driving apparatus in accordance with claim 19, wherein voltages outputted from the first and second driver are 0V when the signal from the waveform generator is equal to the predetermined level.

21. The driving apparatus in accordance with claim 19, wherein the waveform of the first and second driving signals are a sine wave.

22. The driving apparatus in accordance with claim 19, wherein the waveform of the first and second driving signals are a sawtooth wave in which the inclination in a rising up portion is different from that in a falling down portion.

23. A method for driving an actuator having a piezoelectric device serving as a driving source characterized by that:

a first driving signal having a maximum voltage smaller than a voltage of inversion of polarization of the piezoelectric device is applied to the piezoelectric device in a polarization direction; and

a second driving signal having the same voltage but the inverted polarization is applied to the piezoelectric device in a direction opposite to the polarization direction.

24. The method in accordance with claim 23, wherein the second driving signal has a waveform which is an inversion of a waveform of the first driving signal.

25. The method in accordance with claim 23, wherein the waveform of the first and second driving signals are a sine wave.

26. The method in accordance with claim 23, wherein the waveform of the first and second driving signals are a sawtooth wave in which the inclination in a rising up portion is different from that in a falling down portion.